Radiation Analysis of Groundwater Information - Dimock

What is radioactivity?

Radioactivity is the spontaneous emission of energy from unstable atoms. The energy that is released in the process is made up of small, fast-moving particles and high-energy waves. These emissions are typically alpha and beta particles and gamma rays.

What is a radionuclide?

Radionuclides are radioactive isotopes or unstable forms of elements. Radioactivity is the release of energy in the form of gamma rays and energetic particles (alpha and beta particles) that occurs when unstable elements decompose to form more stable elements. The process by which an element changes from an unstable state to a more stable state by emitting radiation is called radioactive decay. Gamma rays, alpha particles, and beta particles, which are given off by radioactive decay, have very different properties but are all ionizing radiation each is energetic enough to break chemical bonds, thereby possessing the ability to damage or destroy living cells.

(*Naturally Occurring Radionuclides in the Ground Water of Southeastern Pennsylvania*. USGS. http://pa.water.usgs.gov/reports/fs012-00.html)

What radionuclides are regulated in drinking water and what are their health effects?

Contaminant	MCL (year promulgated)	Source	Health Effect
Combined radium 226/228	5 pCi/L (1976)	Naturally occurs in some drinking water sources.	Some people who drink water containing radium 226 or 228 in excess of the MCL over many years may have an increased risk of getting cancer.
Adjusted) Gross Alpha.	15 pCi/L (not including radon or uranium) (1976)	Naturally occurs in some drinking water sources	Some people who drink water containing alpha emitters in excess of the MCL over many years may have an increased risk of getting cancer.
Beta Particle and Photon Radioactivity	4 mrem/year (look up table) (1976)	May occur due to contamination from facilities using or producing radioactive materials.	Some people who drink water containing beta and photon emitters in excess of the MCL over many years may have an increased risk of getting cancer.
Uranium	30 µg/L (2000)	Naturally occurs in some drinking water sources.	Exposure to uranium in drinking water may result in toxic effects to the kidney. Some people who drink water containing alpha emitters in excess of the MCL over many years may have an increased risk of getting cancer.

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Why are there standards for some but not all radionuclides?

There are more than 3,000 known radionuclides of which very few are commonly found in groundwater. Maximum Contaminant Levels (MCLs) were established to cover the radionuclides typically encountered in groundwater. MCLs were established for radium and uranium since they are far and away the most commonly encountered. General radiation measurements such alpha, beta and gamma levels were established to identify potential threats posed by other radionuclides for which no MCLs were established.

Other radionuclide analyzed during this project were compared to trigger numbers developed using Preliminary Remediation Goals for Radionuclide calculator. (PRG calculator) PRG calculator numbers are screening levels.

http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/sstbd.pdf.

Can drinking water be contaminated by man-made radionuclides?

A very small percentage of drinking water systems are located in areas that have potential sources of man-made radioactive contamination from facilities that use, manufacture, or dispose of radioactive substances. Drinking water contamination may occur through accidental releases of radioactivity or through improper disposal practices. Water systems that are vulnerable to this type of contamination are required to perform extensive monitoring for radioactive contamination to ensure that their drinking water is safe. These radionuclides are regulated under the "beta particle and photon radioactivity" standard.

http://water.epa.gov/lawsregs/rulesregs/sdwa/radionuclides/basicinformation.cfm

Analytical Reports, Equipment and Methods

Spectroscopy is the use of the absorption, emission, or scattering of electromagnetic radiation by matter to qualitatively or quantitatively study the matter or to study physical processes. The matter can be atoms, molecules, atomic or molecular ions, or solids.

http://www.files.chem.vt.edu/chem-ed/spec/spectros.html

Alpha Particle Spectroscopy - AS - refers to, which is a method of measuring alpha particles.

Gamma Ray Spectroscopy - GS - refers to, which is a method of measuring gamma radiation.

Radionuclide Specific Activity - RS - is a measurement of the amount of radioactivity, or the decay rate, of a particular radionuclide per unit mass of the radionuclide.

What is the Minimum Detectable Concentration (MDC)?

The MDC is the net concentration (in this case radiological activity) that has a specified chance of being detected. It is an estimate of the detection capability of a measuring protocol and is

calculated before measurements are taken. The detection limit is the lowest net response level, in counts, that you expect to be see with a fixed level of certainty, customarily 95%. The MDC is the detection limit expressed as an activity concentration. If the activity concentration in a sample is equal to the MDC, then there is a 95% chance that radioactive material in the sample will be detected.

(http://www.marssim.com/Technical_Questions.htm#faq3_1)

What does 2 σ (two sigma) mean?

A statistical expression that states that approximately 95% of the population lies within two standard deviations of the mean.

What is Uncertainty?

Used in the context of the analytical reports, uncertainty the measurement of total error associated with the counting and measuring process.

Why is the Uranium MCL provided in a concentration (ug/l) rather than radioactivity (pCi/)?

Uranium's chemical toxicity is a higher concern than its radioactivity.

What is a pCi/L (picocurie per liter)?

When we measure the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among radioactive elements. For that reason, one gram of a radioactive substance that decays rapidly may contain the same amount of activity as several tons of another radioactive substance that decays slowly. Activity commonly is expressed in a unit of measure known as a curie. One curie equals 3.7 x 10^{10} (37,000,000,000) atomic disintegrations per second. Activity in water is expressed in units of picocuries per liter (pCi/L), where 1 pCi/L is equal to 2.2 radioactive disintegrations per minute per liter of water.

(http://pa.water.usgs.gov/reports/fs012-00.html)

Other Sources of Information on Radiation

EPA
http://www.epa.gov/radiation/

Agency for Toxic Substances and Disease Registry
http://www.atsdr.cdc.gov/phs/phs.asp?id=482&tid=86

Health Physics Society
http://hps.org/documents/environmental_radiation_fact_sheet.pdf